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Articles PAGE

The Astronomical Work of Samuel Holland, First Surveyor General of Canada, 1764-1801 - *A. F. Hunter* 289

The Nature of Science - - - - - - *H. H. Plaskett* 294

The Total Solar Eclipse, January 24, 1925 - *R. M. Motherwell* 305

Edward Emerson Barnard, his Life and Work *John A. Patterson* 309

Notes and Queries - - - - - - - - - - - - 319

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PLATE VI.

Holland House, Ste. Foy Road, Quebec. From a sketch in the Canadian Archives, Ottawa.

PLATE VII.

Major Samuel Holland, Surveyor General of Canada, 1764-1801.

PLATE VIII.

MAJOR HOLLAND'S ASTRONOMICAL CLOCK.

The case is of two kinds of mahogany, artistically made and highly polished. The pendulum is of the compensation type, made up of alternate bars of steel and brass. The ball is a solid sphere of brass eight inches in diameter.

PLATE IX.

FACE OF ASTRONOMICAL CLOCK.

The face plate is of polished brass. The small circle and hand give the seconds, the large circle and hand the minutes. The upper sector shows the hour of the day, and the lower sector the day of the month. The key for winding the one weight is shown in place. The name of the maker can also be made out.

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VOL. XVIII AUGUST—SEPTEMBER No. 7

THE ASTRONOMICAL WORK OF SAMUEL HOLLAND, FIRST SURVEYOR GENERAL OF CANADA, 1764-1801*

By A. F. HUNTER

As Professor Chant said very correctly in his Convocation Hall address at the end of January, astronomy is the basis of land surveying as well as of navigation. Land surveyors are frequently making observations of the North Star, or Polaris, in order to get the declination of their magnetic compasses and correcting their measurements by this means. Then, too, anyone travelling in a new country, for example, is able to make astronomical observations and ascertain his longitude and his latitude. We have examples of this in some of the early explorers of Canada: Sir Alexander Mackenzie, who traced the river named after himself; and especially David Thompson, who discovered the river named after him in the Rockies. These were men versed in astronomy and some of David Thompson's observations for latitude and longitude are not excelled by the surveyors of the present day.

Ranking with these men was another in the eastern part of Canada—Major Samuel Holland, who was also versed in astronomy. A biography of Major Holland has recently been prepared by Willis Chipman, the Civil Engineer, and has just been published in the last number of the Ontario Historical Society's "Papers and Records". This event,—the publication of this biography of one who was an astronomer, and perhaps the earliest in the British period of Canada,—is one that should not be overlooked in the pro-

*Address before the Royal Astronomical Society of Canada at Toronto, May 20, 1924.

ceedings of this Society and hence these remarks were placed on our programme.

It may be well to speak of Holland with some of the pictures before us (Lantern slides). A few pictures will, perhaps, add a little more interest to the sketch of his life I am going to give. The first (Plate VIII) is his astronomical clock. It will give us an opportunity of comparing the clocks used in astronomy of one hundred and fifty years ago with what are on the wall to-day. The large circle shows the minutes, the small circle the seconds, "just the same as there" (pointing to a clock on the wall of the lecture room). Beyond that, everything is different. The upper sector shows the hour of the day; there is a circle on the present day clock to do that. The lower small sector shows the day of the month, and the key to wind it is in position. The clock is in existence at the present day, but not now running. It is in Prince Edward Island, in Summerside, with one of his descendants. It was an excellent timekeeper, was made by the house of Graham in London, and altogether is a very interesting object.

The next picture (Plate VII) is one of Holland himself, from a miniature painting. Holland was a native of the country called Holland,—born there in 1728, and at an early date he joined the army. Then, as in later years, there was not much waiting from one war to another, so he was in war before he was twenty. Peace came in 1748, when he was about twenty. Then he crossed over to Great Britain and, as you know, the Seven Years' War on this continent began shortly afterwards, in 1754. He joined the British army and, being a skilful draughtsman and engineer, he was with the staff of the Commander-in-Chief, in North America.

The next picture (Plate VI) is his old house, Old Holland House, at Quebec City. That is where he afterward settled down and lived for many years. He bought an old French manor house in the year 1780, and after he bought it he added the cupola, doubtless for astronomical purposes. At any rate, this gives it a very peculiar, nondescript appearance. We are lucky in having this picture preserved; the house has been down for many years.

The next picture is a specimen of his work as a draughtsman.

He was an excellent draughtsman and, as you can see, his work was good. This is a map of a proposed fort near the mouth of the Richelieu River. He made it in the year 1761 when Canada became part of the British Dominions. General James Murray was Commander at the time.

The next one merely shows an important event in his lifetime. Coming through the war as he did, in 1766 he was granted a small tract of land at the foot of the Citadel Hill in Quebec City, and it later became known as the Lower Castle Garden. He did not make use of it, but General Haldimand took it from him. The Governor wanted it for some purpose or other and Major Holland was not able to obtain any redress. There was none given until about 50 years after his death. In 1852 his heirs received a grant from the Government for the property he had lost.

The next one is not just exactly astronomy, but it has something to do with the man who was an astronomer of that period. It is a slide that I had of the death of Wolfe. Holland, as I said, fought through the Seven Years' War, was on the staff of the Commander, Wolfe, and was present at the time of Wolfe's death. It is Benjamin West's picture of the death of Wolfe and I will just read you a passage of Mr. Chipman's account that explains Holland's connection:

"On the Plains of Abraham he laid down a meridian line and set up stone monuments on it near the Jail Hill where Wolfe afterwards fell. On the day of the battle Holland was sent to erect a redoubt to the left, but owing to the rapidity of the French advance he was unable to go and, returning to report to Wolfe, he found him mortally wounded and practically alone. He was carried off the field by Henry Brown of the 28th, and James Henderson, a Grenadier. Holland assisted by supporting Wolfe's wounded arm while they were bringing him down the hill to the right of the 48th. The surgeon's mate of the 48th also joined them. A wounded grenadier rushed up crying, 'the French run', and Holland repeated it, but Wolfe closed his eyes and breathed his last without a groan. He did not utter a single syllable from the time Holland reached him nor were any persons present at his death excepting the four mentioned, Brown, Henderson, Trent (the surgeon's mate) and Holland.

"In West's picture of the death of Wolfe many prominent men are shown who were not even on the battlefield, and to add picturesqueness Indians were included. In Barry's picture only five persons are shown. An article appeared on the death of Wolfe in the Quebec Gazette of July 11th, 1815, in which it was stated that he died in the arms of Dr. Wilkins, and it was also stated that Dr. Tudor attended him in his last moments. In West's portrait Dr. Adair is in attendance. By another authority his head fell on the bosom of Ligonier and he expired without a struggle. There can be little doubt that Holland's account of the last moments of Wolfe is absolutely correct. Our school histories therefore require revision."

That seems to be a correct account and not the one that we read in the histories.

His astronomical work was contributed to the Royal Society in England. There were at least four papers the titles of which are given by Mr. Henry J. Morgan in his Bibliotheca Canadensis:

1. Observations made on the Islands of St. John (the old name of Prince Edward Island) and Cape Breton, to ascertain the latitude and longitude of those places, agreeable to the orders and instructions of the Right Hon. the Lords Commissioners for Trade and Plantations, 1768.
2. Astronomical Observations, 1769.
3. Eclipses of Jupiter's Satellites, observed near Quebec, 1774.
4. Astronomical Observations, 1774.

So he contributed considerably to the astronomy of that period.

Mr. Chipman's estimate is perhaps worth reading here:

"Land surveyors who have occasion to examine the early records of surveys in Ontario, Quebec and Prince Edward Island are probably the only persons who have any conception of the important place that Major Holland held in British North America. There is probably no one man who did more toward the development of Canada than Major Holland."

These facts which I have been bringing out regarding his life are all given in correct detail in the biography that I have mentioned, and it appeared to me that these items regarding his astronomical work should have some notice in our proceedings. In my opinion, he will rank with any of the explorers, and his work was possessed

of a high degree of accuracy. He was the Surveyor-General of Canada from 1764 until his death in 1801, and during that time the Province of Ontario received its first settlers, the United Empire Loyalists. The year 1783 was the beginning of their entrance. He and his deputies, three or four, made the first surveys of this Province, along the St. Lawrence, Lake Ontario and Lake Erie, and made the locations for the incoming Loyalists. In 1792, when Governor Simcoe became the first Governor of Upper Canada (now Ontario) and it was set apart as a separate Province, Holland's health was beginning to break, so an acting Surveyor-General was appointed by Simcoe in 1792 for this Province, and Holland remained the head of the Surveying Department of Lower Canada. It seemed advisable to bring out these facts because of the importance of his career and the importance of his work in Canada.

(Following a few remarks by Allan F. Miller, in the course of which the speaker humorously observed that he preferred the legend of the history books to the cold facts of Wolfe's death which had just been recited, Mr. Hunter added a few words to his address.)

During that Seven Years' War he kept very full notes, wrote a diary,—indeed, a history of the war; and very soon after, in 1762, when he was travelling in England, it was stolen from him—his portmanteau was stolen,—and he afterward regretted it during all his life. In going over Mr. Chipman's manuscript I noticed this and called his attention to the fact that in the Reference Library in Toronto there is such a manuscript history of that war never published. It is in what is called the D. W. Smith MSS. and its localities correspond very closely with places where Holland had been during the war. There is no name of author on it, however. He examined the manuscript in the Library closely, and I did so independently. We found many of the capital letters the same as Major Holland made in writings which we know were Holland's, and we both came to the conclusion that in all probability that is the missing diary here in our Toronto Reference Library. It was purchased a number of years ago from a Glasgow or Edinburgh bookseller and would be a valuable history of the war if it could be put into prin.t. I mention that as it is of some interest in Toronto.

THE NATURE OF SCIENCE*

By H. H. PLASKETT

THE failure of thoughtful people more widely to adopt the descriptive view of science shows to some extent that its simplicity and important implications have not been completely understood. And yet this view, if for no other reason than that it was originated by such masters as Kirchhoff, Mach and Poincaré, is worthy of the attention of all students of science. There is then, perhaps, room for an article which will give a concise account of this view and serve as an introduction to Hobson's authoritative *Gifford Lectures* or Pearson's *Grammar of Science*. The present article represents an imperfect attempt to meet this need; the descriptive view of science is here discussed under the headings of facts and their classification, laws and theories and finally the relation of science to philosophy.

1. *The Facts of Science and their Classification*

Facts form the subject matter of science. A distinction must, however, be recognized between the primitive facts which result from our sense impressions and those facts, ordinarily obtained in science to-day, whose very existence depends upon a number of accepted theories and laws. Even so simple an operation as the measurement of a length involves the pre-existence of some system of geometry, while the determination of a stellar position can be shown to depend upon at least a dozen scientific laws. In their origin, however, these facts, now a consequence of laws, were none other than primitive facts dependent upon sense data; a discussion of these sense data should then reveal the essential nature of the facts of science.

Before me, as I write, there is a table. From the table I receive and recall by memory certain sense data of colour, smoothness,

*From a lecture before the Victoria Centre of the Royal Astronomical Society of Canada.

shape, hardness and sound when it is rapped. While generally I may describe the table as brown, it must be admitted that the colour varies as I move about the room and also depends upon the quantity of light falling on the table. Again, while the table appears smooth to my unaided eye, with a microscope it would appear rough and uneven; similarly the shape varies with my position, and the hardness depends upon how strongly and with what part of my body I press upon the table. Indeed I would find it difficult to state what the "real" colour, smoothness, shape and hardness of the table are, although I can describe the apparent table so that it is immediately recognizable to anyone else. The *apparent* table depends upon us, its observers, and we do not seem able to disentangle the *real* table from our sense data. Indeed the real existence of the table apart from us who observe it, may be and has been doubted; its actual nature, if it does exist, is not and perhaps never will be known. But though the real table is not known, the existence of the sense data, on the other hand, cannot be questioned. Science, on the descriptive view, is therefore content to take as the fact, that which cannot be doubted, the sense data. The table is thus, for science only a construct made up of immediate and recalled sense data. There may be some "thing in itself" which gives rise to these sense data, but this strange thing which we can know only imperfectly, if at all, is not the fact for science; that fact is simply the sum of the sense data.

Science imposes two limitations on the facts which it discusses, the limitation of universal assent and of frequent repetition. In the first place the facts or perceptions discussed must be only those to which everyone agrees; an experiment or an observation, to form part of the subject matter of science, must be reproducible by any worker. The relative backwardness of psychical research, in spite of forty years work by the great English society, may be attributed with some certainty to a subject matter made up of facts to which not every one assents. In the second place the facts to be discussed must be common; they must frequently thrust themselves upon our attention. If, as Poincaré has supposed, there had been 10^9 equally abundant elements in place of 88, so that every pebble we picked up had been a different element, then the science of chemistry would not have been possible. This

second limitation, however, only operates at the initiation of a science; once the science is established the subject matter is by no means limited to common facts, but is extended to include peculiar and infrequent events.

Facts, which are simply sense data and which are subject to the limitations just described, form the subject matter of science. The first step in their use is an apportionment of these facts to various branches of science. Thus botany treats of facts relating to plant life, astronomy of observations of the heavenly bodies, mineralogy of the components of the earth's crust, and so on. This apportionment is an approximate application of the method of classification, which may be defined as the grouping together of facts which have some property in common. Classification is not only used in the division of the subject matter amongst the various branches of science, but it is also historically the first method used in the sciences themselves. An example will make its nature clear. One of the earliest classifications of the stars was by their apparent brightness; in Ptolemy's catalogue all the stars visible to the unaided eye were grouped into six classes or magnitudes. This classification has been retained to the present day, in spite of the fact that stars of the same apparent magnitude may differ in distance, in motion, in temperature and in mass. In short when we speak of stars of the third magnitude, say, we *abstract* all those qualities in which the stars differ and consider the one property, apparent magnitude, which they have in common. A star of the third magnitude is a concept, which enables us to summarize a group of facts. Throughout this paper the word *concept* will be used to denote an abstract idea devised by the mind of man which may, or may not, correspond to some construct of sense data or percept in the external world. Classification is then the description of groups of facts by the aid of concepts, in which abstraction is made of the differences and the attention concentrated on the similarities common to the group. Classification is among the more powerful methods of science, and in some branches almost the only successful method used up to the present time.

2. *The Laws and Theories of Science*

Even the most casual examination of our experience reveals the association of certain facts; in some cases this association is so uniform as to give us a considerable power of prediction. When the sun sets at night we anticipate it will rise on the morrow, if we release an object we expect it to fall, if we omit our dinner we will be hungry, and so on. It is the association of facts, of which these are simple examples, that it is the fundamental business of science to study, and the results of this study are expressed in laws and theories.

An appreciation of the nature of laws and theories can be most conveniently reached from a consideration of the results in some branch of science; for this purpose optics is particularly suitable. Some of the phenomena in optics, such as the reflection of bushes and trees or the apparent bending of a stick in water, must have been familiar even to the most primitive people. By the time of Plato these facts had been so frequently studied that it was possible to state two definite relations. The first of these was that light travelled in straight lines. In this statement there are two concepts, a straight line, which is a well known abstract idea in Euclid, and light a concept devised for the purpose of optics. No one in fact has ever seen, or heard or felt light; it is a purely mental invention of Plato and his students. With the aid of these two concepts the relation describes in short hand form the phenomena of shadows and pin-hole images. The relation is a proto-type of the laws of science—a conceptual description of perceptual experience; it is not an objective law which Nature of necessity obeys; it is only a description of a strictly limited series of facts. The second of the relations stated by Plato was the equality of the angles of the incident and reflected beams—likewise a purely conceptual description of experience in which the concepts are geometrical. Though Ptolemy had drawn up tables of the angles of incident and refracted beams, neither he nor Kepler much later were able to summarize these facts in a single statement. It was left for Snell in the seventeenth century to discover the law of refraction, which again is none other than a simple conceptual description of experimental facts, though a description which

must excite admiration for its deviser. By the aid of these three laws on the rectilinear propagation, reflection and refraction of light we are able to describe conceptually a large number of hitherto unrelated facts. But physicists were not satisfied and sought, in the language of the older view of science, a physical explanation of these laws. Two rival theories were proposed, one of which stated that light was composed of minute corpuscles travelling in straight lines, and the other that light was a wave motion in the ether. On the descriptive view of science we recognize that these theories are also simply conceptual relations, no different in character from the laws. The theories are merely wider in scope and are designed by the mind of man to summarize the laws and other facts, previously uncoordinated, in one comprehensive statement. In these theories the corpuscles and the ether are concepts, whose properties have been so postulated that an adequate description of the facts will result. While each of the theories is equally self consistent and the deductions alike logically necessary, the wave theory alone has survived, because with the minimum number of postulates, it has described a greater range of perceptual experience. Without further reference to optics we may conclude, on the view of science now being advanced, that laws and theories are simply conceptual descriptions of large numbers of facts. While in general a theory summarizes a greater body of facts than a law, the term applied to the descriptive formula is largely a matter of historical usage; thus the most remarkable theoretical generalization ever devised is called the law of gravitation.

This new descriptive view of science is characterized by two marked differences from the older view. One of these, already discussed, is that no assumption is now made as to the "real" nature of external objects which are regarded for the purposes of science only as constructs of present and past sense data. The other difference, which must here be stressed, is that the notions of efficient causation and necessity applied to external phenomena are also rejected. When I move a chair, or throw a ball, I regard myself as the cause of the resulting motion; such causation is termed efficient. This notion has been transferred to natural phenomena so that, when an event A invariably precedes an event B, A is regarded as the efficient cause of B—that is the

occurrence of A is supposed to force the occurrence of B. This notion, which has played a very important part in the history of science, is implicit when we seek explanations; for example when we ask why does a body fall to the ground we are seeking an efficient cause. In the final analysis it must be admitted that all we do is describe how the body falls, we have never found why it falls. Again the notion of efficient causation is at the bottom of the distaste for action at a distance. Just as I, the efficient cause, have to be in contact with the chair before I can move it, so scientists, including Newton, have felt that there had to be interaction of some material bodies to explain the law of gravitation. While these various notions arising out of efficient causation may be perfectly valid, on the descriptive view they are no longer needed. Again it is logically necessary, according to the law of gravitation, that two mass points should revolve in elliptical orbits about their common centre of gravity, describing equal areas in equal times; but this necessity cannot be transferred from the conceptual theory to the natural phenomena. For there is no necessity that the earth should revolve about the sun in this manner, and no assurance, only a high degree of probability, that it will so continue to move to-morrow. In short, science is not concerned in the search for possible efficient causes or for necessity in Nature, but is content to describe conceptually what we observe.

A law or theory is "true" on the descriptive view of science when it is logically consistent, when it describes adequately the facts which it was designed to summarize, when it is simple and when it has a power of prediction. These four requirements may be considered in turn.

(1) Logical inconsistency may arise in framing the concepts and postulates of a theory; an example is the ordinary dynamical theory where, as Mach pointed out, force, work and kinetic energy are not independent concepts but are derived from the fundamental concepts of mass, space and time. Or logical inconsistency may arise in the development of a theory, where owing to mathematical difficulties, physicists err as to the deductions from the postulates. An example is the long controversy on the stability of the pear-shaped figure of equilibrium in the theory of a rotating incompressible fluid.

(2) A law or theory may be logically consistent and yet fail to describe the facts for whose description it was invented. On the caloric theory, heat was due to a universal, indestructible and uncreatable fluid which was also elastic and self-repellent; this fluid of course was simply a concept with certain postulated properties. Expansion of heated bodies was thus conceptually described by the self-repulsion of the caloric, specific heat by the varying attraction of different materials for the fluid and the heat developed by friction or percussion as caloric pounded or abraded out of the body. The theory failed, however, adequately to describe friction, in so far as Count Rumford showed that the heat there developed was inexhaustible. But caloric on its postulated properties was uncreatable and hence the theory, while still logically consistent, failed to describe one of the very facts it was designed to summarize.

(3) Successful theories tend to the greatest simplicity and abstraction. If a theory is devised with certain concepts which on account of metaphysical leanings, seem necessary to its creator, those concepts either prove the ultimate un-doing of the theory or are in the course of time eliminated. To the Greeks the fixity of the earth and motion in circular orbits were such necessary concepts. But the observed movements of the planets could not be described by simple circular orbits with the earth at the centre, and so it was necessary to postulate that the planet moved in an epicycle, or small circle, whose centre in turn travelled about a larger circle, or deferent, described about the earth as centre. We already note a considerable complication which with more refined observations had to be so greatly increased, that the Ptolemaic theory became un-usable. On the other hand the second law of thermodynamics, as first stated by Carnot, contained the concept of the caloric; this concept proved unnecessary to the law and has been omitted in all subsequent statements.

(4) The ultimate test of the validity of a theory lies in its power to predict phenomena outside the range of facts it was designed to describe. Newton's corpuscular theory of light furnishes a simple, logically consistent description of the observed phenomena of rectilinear propagation, reflection and refraction. It failed, however, to predict the retardation in light velocity in a dense

medium and the phenomena of interference and diffraction; it was accordingly superseded by the wave theory which did predict these facts. Again the great success of the quantum theory has been due to its applicability to the description of the photo-electric effect, the production of X-rays and the origin of line spectra, whereas it had its origin in an attempt to describe the phenomena in the very limited domain of heat radiation.

3. *The Relation of Science to Philosophy*

A satisfactory view of the purposes of science should not only provide an adequate account of the nature of scientific results, but should also be based on the minimum number of metaphysical postulates. For it is unfortunately true, as a result of the very nature of philosophical enquiry, that the results of such enquiry do not receive universal assent. In any attempt to determine the nature of existence—the central problem in philosophy—the only method of attack is first, as a result of critical discussion, to form a self-consistent group of instinctive beliefs, and then on that foundation logically to erect a system of thought. As, however, the instinctive beliefs of a philosopher are the result of his early environment and education, it follows that there are numerous self-consistent but mutually discrepant systems of philosophy ranging all the way from solipsism, in which existence is regarded merely as a dream, to naive realism, in which things are assumed to be exactly as they appear; and further it follows that none of these systems, on account of the a-logical character of the beliefs on which they are founded, can be shown to lead to logical absurdity. If science is to be independent of such uncertainty, it is clearly essential that metaphysical notions like physical realism and efficient causation, though hitherto regarded as essential for the purposes of science, should now be discarded. It is characteristic of this new view of science that its basic postulates are independent of the results of metaphysical thought; accordingly it is true that, *when science is regarded only as a description of our experience, such a description is valid for all men, irrespective of their philosophical leanings.*

Three fundamental postulates are implicit in our earlier discussion of the descriptive view of science. (1) It is postulated

that there is a distinction between what goes on within ourselves and what happens without—the ordinary dualism of mind and matter. This assumption is provisional and methodological—that is even if philosophers should ever be able to prove that mind and matter are aspects of some underlying units, the results of science based on this postulate will still hold good. (2) It is postulated that the facts of science are merely constructs of present and past sense data. The method of systematic doubt, initiated by Descartes, seems to show in the final analysis that the only things of which we can be sure are these sense data. This assumption is also methodological, for even if philosophers can ever show that our sense data have any correspondence with some "shadowy thing in itself" behind phenomena, science will still serve to describe what are the facts for us, our sense data. (3) It is postulated that sequences of facts can be found which are describable by conceptual schemes. This assumption is basic to all knowledge; if for example we found that fire was sometimes hot and sometimes cold, or that bread was at times nourishing and at other times poisonous, we could never have developed mentally as we have, even if we could have survived so confusing an experience.

The general nature of the philosophical difficulties avoided in these postulates has been indicated in the brief discussion of each. It might, however, be well to stress further some of the philosophical implications of postulates two and three, involving as they do the rejection of physical realism and efficient causation, notions which have been of great importance in the past history of science and which are still widely held by scientists. When we perceive a table, while the scientist on the descriptive view is content to describe conceptually his sense data, the philosopher seeks to penetrate behind appearance to reality. If he is an idealist, the philosopher will regard the thing in itself, behind the sense data, as an "idea" either in the mind of God or the collective mind of mankind. If the philosopher is a realist, and in particular a physical realist, he will regard the table as composed of molecules, atoms and electrons; he will explain the sense data which he receives from the table as due to the notions and interaction of these minute, but real bodies. Now the physical realist, though he is in the minority amongst those competent to discuss such abstruse

matters, may be right; but he can neither prove that he is right nor show that views divergent from his lead to logical absurdity. On account of this very uncertainty the notion of physical realism is, therefore, not retained in the descriptive view of science; on this view molecules, atoms and electrons are concepts devised by the mind of man for the sole purpose of describing phenomena. They may be "real", but such an assumption is not necessary, and is therefore not used in this view of science. Similarly the notion of efficient causation, which has previously been discussed, is not essential for the purposes of the descriptive view. Those philosophers who seek efficient causes may be and probably are right; it must, however, be admitted that in science an efficient cause has yet to be found. It is therefore sufficient to replace this notion by our third postulate, namely that sequences of phenomena can be found, so far without limit, for which conceptual description can be given. In this connection a word of caution is necessary. Plato with his "ideas", and very recently Bertrand Russell with his "universals", believed that these ideas and universals, which are none other than our concepts, formed a "real" world more important than the outside world of sense data. While they may be right, on the descriptive view of science no such assumption is necessary. On this view the concepts are regarded as purely mental inventions designed solely to describe phenomena.

In connection with the relation of science to philosophy something should be said about materialism and the denial of the existence of God. There have been and are a number of philosophers who regard the whole of experience as dictated by unalterable laws of Nature; these laws are valid from the infinite past into the infinite future and apply to the whole universe. It is these laws of Nature, which it is, so they claim, the business of science to discover; and they point to the vast achievements of science as evidence of the soundness of their philosophy. With regard to these views it may be pointed out that science has heretofore found laws applicable only to finite portions of space and valid for finite intervals of time; it is scarcely legitimate on these meagre grounds to infer the existence of laws operating over all time in the whole universe. Again the laws and theories found

by science are, on the new view, purely descriptive of our experience; without some metaphysical assumptions, unnecessary for its own purposes, science cannot be regarded as discovering objective laws which Nature must obey. In fact materialism, as well as realism and idealism must stand or fall on their own merits; on the descriptive view, science cannot be regarded as lending support to any system of philosophy. Similarly the fundamental problems of theistic philosophy on the existence of God and His nature are problems to which science on the descriptive view cannot contribute. If science is, as we believe, independent of metaphysical uncertainties, it is equally true that philosophy and religion are independent of scientific achievements.

In conclusion we must recognize that the descriptive view, in spite of the rejection of the notions of physical realism and efficient causation, has served to present a self-consistent and complete picture of the purposes of science. Whatever the ultimate verdict on its value may be, a study of the descriptive view cannot fail in Pearson to stimulate and in Hobson to clarify thought on the functions of science. This article will accordingly have served its every purpose if it directs its readers to Pearson's *Grammar of Science* and Hobson's *Gifford Lectures*.

Victoria, B.C.

THE TOTAL SOLAR ECLIPSE, JANUARY 24, 1925

By R. M. Motherwell

There will be four eclipses in 1925, two of the Sun and two of the Moon. The lunar eclipses, occuring on Feb. 8-9 and Aug. 4, are only partial and visible in only restricted areas of North America. The second solar eclipse, occurring on July 20-21, is annular and visible only in the Southern Pacific Ocean.

The solar eclipse of January 24, however, is total and the path of totality crosses over a thickly populated district, several observatories, including those of the University of Toronto and Vassar College, being in the path of totality. The accompanying maps show the path of the eclipse.

Figure 1 gives the paths of both partial and total eclipse. The heavy curved lines to the left indicate where the partial eclipse ends at sunrise, is half over at sunrise and begins at sunrise. The curves to the right give the corresponding phases occurring at sunset. The point to the left marked "first contact" is where the moon's shadow first touches the earth and "last contact" to the right is where the moon's shadow leaves the earth. These two phases of the eclipse occur naturally at sunrise and sunset respectively. The dotted lines indicate the positions of the moon's shadow on the earth at the even hours and the path of totality is marked by the two heavy parallel lines. It will be noted that about three-fourths of the path of totality is on the Atlantic Ocean. The western end of the path where the eclipse occurs in the early morning is the only part on land, and consequently the conditions for observation are rather unfavourable.

Figure 2 gives more details of the part of the total phase that occurs on land. The scale of the map is about one hundred miles to the inch and the accompanying table gives the circumstances of the eclipse for several cities and towns so distributed that it is a

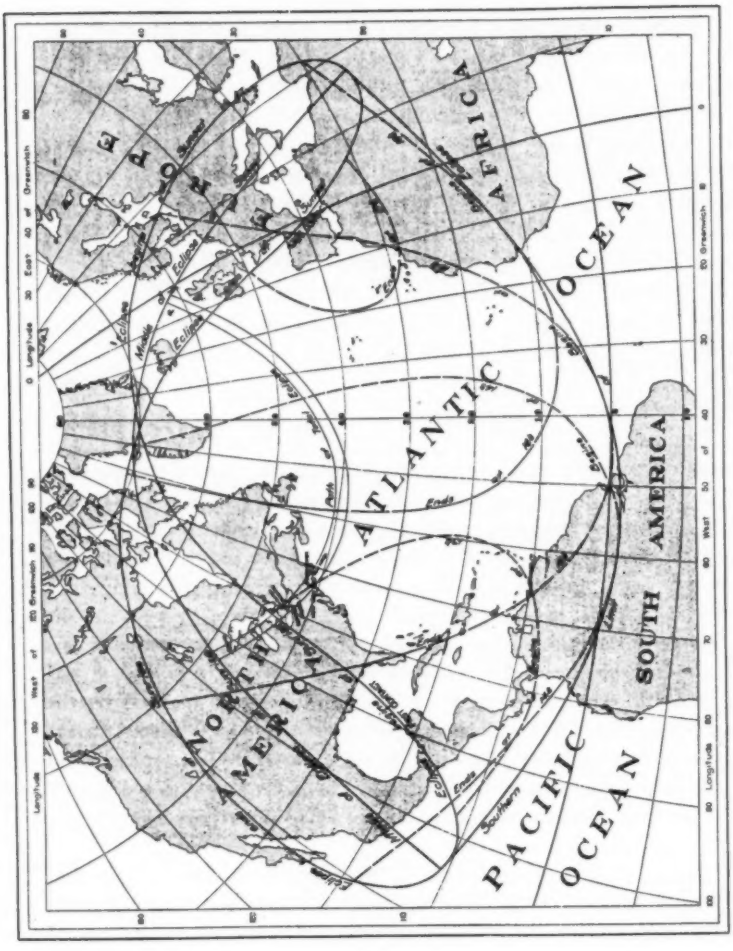


Fig. 1.—Circumstances of the Total Solar Eclipse of January 24, 1925.
(*From the Nautical Almanac*)

(*From the Nautical Almanac*)

TOTAL SOLAR ECLIPSE, JAN. 24, 1925.

Place	Beginning		Total Eclipse				Time of Maximum	Ending		Magnitude
	First Contact	Pos. Angle	Second Contact	Pos. Angle	Third Contact	Pos. Angle	Eclipse	Last Contact	Pos. Angle	
	h m s	°	h m s	°	h m s	°	h m s	h m s	°	
Halifax	9 15 16	260					10 30 42	11 51 12	85	0.92
St. John	9 13 20	260					10 27 26	11 46 54	88	0.92
Quebec	8 10 29	260					9 21 46	10 38 45	88	0.92
Montreal	8 06 44	262					9 17 01	10 33 50	87	0.95
Ottawa	8 04 38	263					9 14 16	10 30 13	87	0.96
North Bay	8 03 25	263					9 11 13	10 25 15	87	0.96
Kingston	8 02 22	264					9 11 50	10 27 57	86	0.98
Toronto	7 59 35	266	9 07 09	37	9 08 21	314	.....	10 22 40	85	1.02
Harriston	7 59 04	266	9 06 03	43	9 06 59	308	.....	10 20 39	85	1.02
St. Catharines	7 58 59	267	9 06 24	64	9 08 09	275	.....	10 22 39	84	1.03
Guelph	7 58 55	267	9 05 49	71	9 07 32	280	.....	10 21 13	85	1.03
New York*	7 59 32	267	9 10 31	161	9 11 02	190	.....	10 29 13	83	1.02
Port Stanley	7 57 09	268					9 04 30	10 18 46	84	0.99
Windsor	7 55 46	269					9 02 12	10 15 35	85	0.98

*Columbia University Observatory
Halifax and St. John, Atlantic Standard Time—all other points Eastern Standard Time

simple matter to approximate the times for intermediate points. The heavy line running nearly north and south from James Bay through Lake Huron marks where the partial eclipse begins at sunrise. Figure 1 shows that the partial eclipse begins at sunrise or later in the older part of Ontario, Quebec, Newfoundland and the eastern part of the United States.

In Figure 2 the dotted lines indicate the points of beginning of totality along the central line at five minute intervals, the corresponding standard times of these intervals being marked above the heavy extensions of the dotted lines and the duration of totality as seen on the central line is marked below the heavy lines. For points not on the central line but yet inside the path of totality the duration of totality decreases as the distance from the central line increases. The numbers which are marked under several cities outside the path of totality indicate the fraction of the sun's diameter (in hundredths) covered by the moon at maximum eclipse and the table gives the times of maximum eclipse for these points. The position angles in the table are measured from the north point of the sun's limb towards the east.

The time of year renders very remote the possibility of fine weather, the low altitude of the sun is unfavourable for observation and the temperature is likely to be low. Even so a total solar eclipse is of sufficiently rare occurrence to warrant a lengthy trip in order that one may be as near as possible to the centre of the path of totality. Decide where you will locate in the path, obtain from the map the time of the eclipse at that point, choose a spot from which you can see the surrounding country—especially westward—and watch carefully in that direction as the time of the eclipse draws near. If your point of observation is sufficiently high you will see the shadow as it rushes toward you, a truly grand and awe-inspiring sight which you will never forget.

Dominion Observatory, Ottawa.

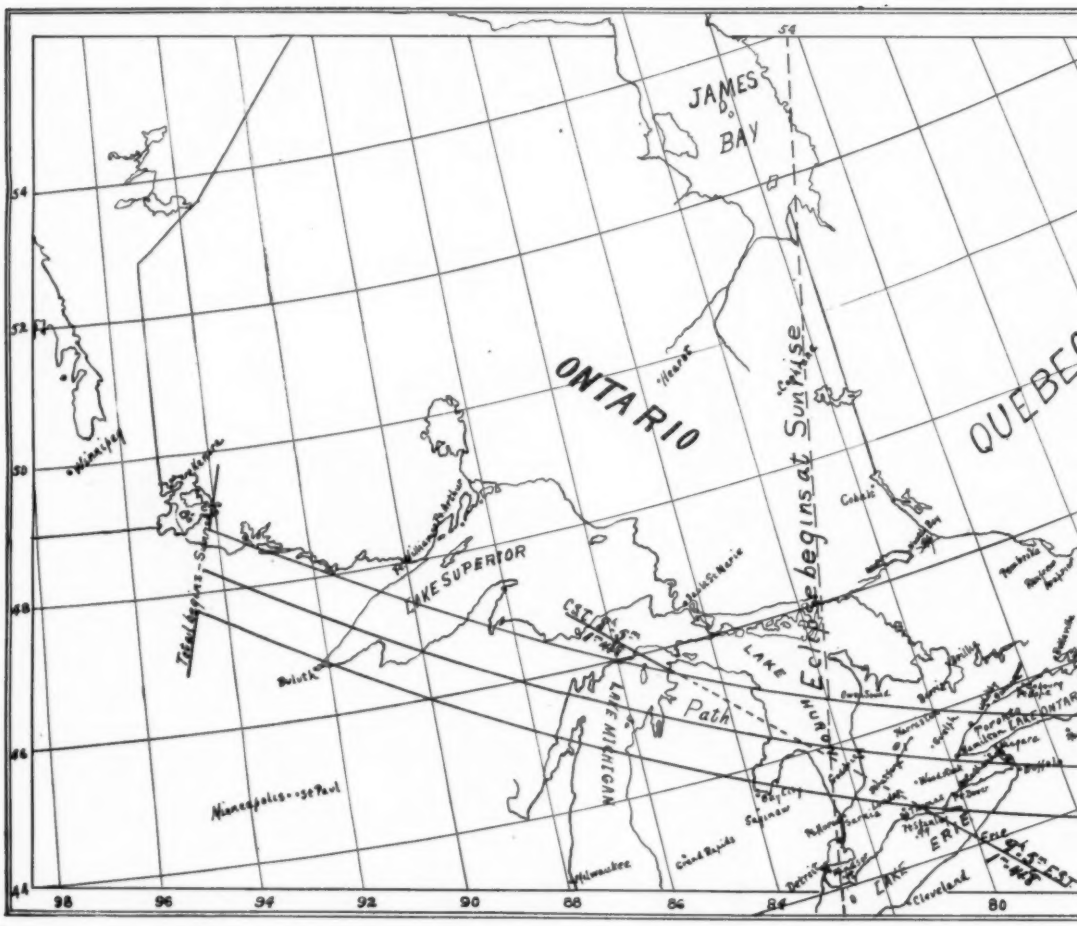
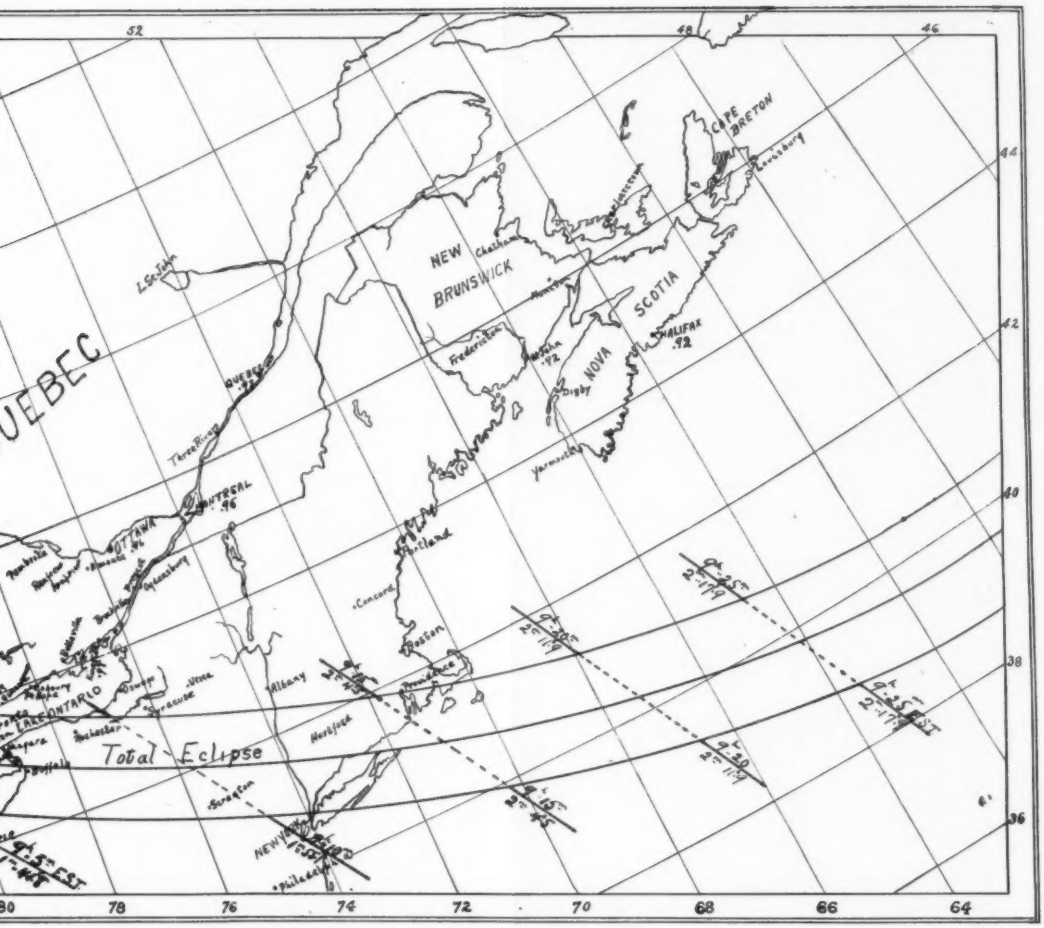


Fig. 2.—Total Solar Eclipse of Sunday, January 24th, 1925; M



, 1925; Map showing path across Ontario and United States.

EDWARD EMERSON BARNARD; HIS LIFE AND WORK

By JOHN A. PATERSON

WE all like to know great men. We all like to touch great men even physically and still more so intellectually. There is something broadly human in the relic hunter and the souvenir collector. The worshipper cannot be satisfied with a vague idea, hence the idolator clutches something physical, and it is the same principle that actuates the worshipper at the shrine of any leader among men. Do you recall how Browning looked upon a man who had spoken to Shelley?

> "And did you once see Shelley plain,
> And did he stop and speak to you,
> And did you speak to him again?
> How strange it seems and new!"

Let us try and see Bernard plain and let him stop and speak to us through the many and convincing records we have and thus we will know him better and perhaps touch the secret springs of his great and brilliant success. And after all we will find that there is nothing new in these springs, for they are as old as Hipparchus, whom Ptolemy describes as a "labour-loving and truth-loving man; aye and even older, for genius is after all the faculty of taking infinite pains".

There is a great attractiveness in opening a parcel; the mystery of its contents, the anticipation of a pleasant discovery, the possibility of disappointment. All these tend to create interest until the string is untied, the paper stripped off, the box opened and then all is revealed. The parcel I open to-night has been opened before by very skilful hands and all I can venture to do is to untie again the string, strip off the covering again, open the box and place the contents before you with the hopes that some part of it may not have been seen before by my patient hearers, and whatever part has been

seen before may by a humble hand be lifted from its box, and placed upon the table of your attention in a more familiar manner for you to view it more closely, but not for me to show it more skilfully. A man of large affairs, one of wealth and renown, to whom was given wisdom, "even as the sand which is on the sea shore"—the son of a king and who ornamented a kingly throne with a royalty of mind far beyond the wisdom of his day, wrote: "Seest thou a man diligent in business? He shall stand before kings: he shall not stand before common men." The man we speak of to-night was truly a man diligent in business in the domain of Astronomy; he laboured assiduously; he struggled nobly and attained a pre-eminence that placed him among the most gifted men of this earth. And truly he stood not before but among kings, and was the friend and confidant of prophets, priests, princes and kings of Science divinely endowed with the very highest intellectual power. He was truly honoured by his fellowmen, but his real patent of nobility came from a higher source which said "Behold I have sent thee forth mortal man, to make further and greater discoveries in my boundless universe, to add to the sum of human knowledge of the number of my blazing thrones that proclaim the power and wisdom of their Creator, to lift up to higher things the contemplation of men from the lower but yet necessary things of this earth, my footstool, and so to enlarge the contemplation of my Universe. I endow thee with perception first, to see the truth, then to prove the truth, anl last of all to proclaim the truth, that all these battalions of discovered and yet to be discovered shining hosts, obey the laws of my Universe and so prove my power and creativeness and providence."

Edward Emerson Barnard was born at Nashville, Tenn., on the 10th of December, 1857, the son of poor and little known parents. His father died before his birth and his mother, who was a woman of character, was left to support herself and her two young sons. But she did not lose her heart for culture and her noble ambition to do all possible for her children, even in her struggle with grinding poverty. She had, like many of the daughters of adversity, a soul above her station; and in testimony of her admiration of Ralph Waldo Emerson, the poet, preacher and philosopher, she gave his

name to her second born. But what is much more important, this good mother impressed upon her boy self-reliance and the earnest purpose of looking forward and upward. This astronomer in embryo attended the common school only two months in his whole life, and yet put himself by sheer force of natural aptitude and industry in the fore-front of observational astronomers. A photographer in Nashville had on the roof of his studio a ponderous enlarging camera which had to be kept pointed at the sun. Young Edward, then nine years old, commenced his brilliant astronomical career by acting as a human substitute for a driving clock, and worked there in other capacities for 17 years. His duties then were monotonous, but his vision widened both physically and mentally, when by accident he found the small objective of a broken spy glass. He made for it a paper tube and thus commenced his study of the heavens. He afterward by chance fell in with a volume of the works of Thomas Dick, the astronomer, and thus, by a series of accidents or providences, his life-work was settled for him. When other young men aspiring to fame through study and scholarship, or to scholarship without fame, were toiling on or perhaps at school or the University, Barnard was developing his passion for astronomical observation.

Although he was compelled by dire necessity to support his mother as well as himself, through rigid economy he purchased in 1876 a five-inch equatorially mounted telescope for $400.00. This was two-thirds of a whole year's earnings, but he was bound to rise and with the utmost zeal toiled on. In 1877 the American Association for the Advancement of Science held its Annual Session at Nashville, and this youth of twenty brought his telescope and presented himself to the President, Simon Newcomb. This distinguished astronomer, already eminent at the age of 42 in the domain of theoretical astronomy, measured up young Barnard and advised him to study mathematics. No doubt at this time of his life he could not have solved a quadratic equation, and the "cross-grained Muses of the cube and square" were to him absolute strangers. However, he determined to court these ladies, and succeeded in becoming somewhat skilled in elementary mathematics,

although the mysteries of the Differential Calculus, and Fluxions and Newton's *Principia* were to him absolutely unknown. But to him it was given not only "to scorn delights and live laborious days" but also nights. To the study of mathematics he diligently applied himself and out of his small earnings he engaged a tutor who assisted him over many a hard spot, and helped to bring down the branches of the Tree of Knowledge, and then he eargerly ate of the fruit thereof, and distributed the fruit to all who likewise wished to eat of it. It has been said, "whether or no a man will be famous let us ask his mother." For as Tennyson says in the *Princess,* "the training of a child is woman's wisdom—the mother makes us most." Napoleon Bonaparte was asked, "what does France need most?" and he answered *"bonnes mères."* True it is that home is the first and most important school of character.

A great Scottish philosopher, Thomas Carlyle, gave utterance to a weighty statement, "Produce, produce, produce something even if it be but the pitifulest infinitesimal fraction of a product—produce it in God's name—the only monster in this world is the idle man! Blessed be the man who has found his work, let him ask no other blessedness." Yea verily Barnard in the end found his work, and deserved and reached his blessedness. Barnard was not like Sir Robert Ball, another great astronomer, brought up amongst artistic and scientific surroundings, but he worked to win, and gave his mother who sacrificed so much for his sake the holy joy of victory. He had the ability, he had the physical health and strength, and he had the poverty which, as in the case of the great Samuel Johnson and many others, flogged him to the winning post. For a minute I digress to record an incident in Samuel Johnson's career—which illustrates. He was in great poverty and entered Pembroke College, Oxford, as a sizar but could not complete his course. After that he struggled on. He was a man like Barnard. He might be conquered, but he would never surrender. A kind friend of Johnson's noticed that his boots, in the cold wet weather of an English winter, showed yawning openings, and so this friend quietly placed a pair of new boots in his bedroom. What followed is told by a friend who secretly witnessed. The great awkward Johnson with

shambling gait stalked in, his blazing eyes saw the boots, a deep flush of anger and humiliation covered his cheeks; one moment he hesitated with the offending boots in his hand, opened the window and without a word flung them into the street. It was not polite, it was not grateful, but we cannot but admire the sturdy independence of that great man. I cannot but digress still further, as a native Scot my heart thrills with admiration for Bobby Burns. Hear his immortal and oft quoted lines:—

Is there, for honest poverty,
That hangs his head and a'that?
The coward slave, we pass him by,
We dare be poor for a'that!
For a'that and a'that,
Our toil's obscure and a'that;
The rank is but the guinea stamp,
The man's the gowd for a'that.

What tho' on hamely fare we dine,
Wear hodden-gray, and a'that;
Gie fools their silks, and knaves their wine,
A man's a man for a'that.
For a'that and a'that,
Their tinsel show an' a'that;
The honest man, tho' e'er sae poor,
Is king o'men for a'that.

Edward Emerson Barnard no doubt often in his notable career dined on "hamely fare, wore hodden-gray and a'that" but he certainly was "king o'men for a'that." But let me go back to the broad highway of my subject. Had Homer been the son of a Greek plutocrat with drachmas to spend, would we have had his wonderful epics which have been the admiration and despair of so many renowned prophets, priests and kings in the literary world? Remember that for this "blind old man of Scio's rocky isle" it was true that

Seven cities claim the mighty Homer dead,
Through which the living Homer begged his bread,

and thus Achilles and Ulysses and the Atridae became our companions and household words. But we must return to the sober

continuity of history. It is a great inspiration to read and hear about the great astronomers from Newton the great discoverer of the universal law of gravitation that reigns in the mighty Sirius as well as the other gigantic suns—the law of gravitation I repeat, that also guides the tear of sympathy and love that courses down the cheek of beauty—The names of these great discoverers, observers and teachers are as legion. We think of Lord Kelvin, Clerk Maxwell, Lockyer, Hale, J. Couch Adams, Simon Newcomb, Airy, Huggins, Struve, Sir Robert Ball, Sir David Gill and many others, and now last but not least, Edward Emerson Barnard. He was born 16th December, 1857, and on the 6th of February, 1923, the curtain of his earthly life was rung down. I have before me a record of his greatest achievements supplied by Dr. C. A. Chant, without whose work and inspiration this Society would lose one of its greatest lights and most learned instructors.

On the 25th March, 1920, a most interesting lecture was delivered by Dr. Barnard who was at that time and for many years before then, Astronomer in the Yerkes Observatory of the University of Chicago, on "Photographic Revelations in Astronomy" illustrated with lantern slides under the auspices of the University of Toronto and our Society. The record supplied me is as follows:

> Professor Barnard is one of the greatest of living Astronomers. He was in charge of the Vanderbilt University Observatory at Nashville, Tenn., 1883-87; Astronomer in the Lick Observatory, 1888-95; and Astronomer in the Yerkes Observatory since 1895. Between 1881 and 1892 he discovered 19 comets; in 1892 he discovered Jupiter's fifth satellite: and in 1916 he discovered the star with the greatest known proper motion. Indeed his contributions to every branch of observational astronomy have been numerous and important.
>
> Among his marks of recognition are the Lalande, Arago and Janssen gold medals from France; the Royal Astronomical Society's gold medal from England; and the Bruce gold medal in the United States.
>
> Professor Barnard's best known work is his unrivalled series of photographs of comets and the Milky Way.

To that record I add that in 1909 our own Queen's University at Kingston conferred upon him the honorary degree of LL.D. Much more could be added did time permit. The results in comet

seeking are the reward of industry and systematic sweeping of the sky. Such famed observers as Swift, Perrine, Tempel and Brooks bear witness to that. Genius has been defined as the "capacity of taking infinite pains in small things", and Barnard had it. As a comet finder he made for himself a high reputation, and in 1883 was rewarded with a fellowship in Astronomy at Vanderbilt University. Mr. Warner, the rich owner of a great proprietary medicine, rewarded him with the sum of $200 each for many of his discoveries.

I find in an article in *Popular Astronomy* a most excellent digest of Barnard's scientific career. At the University of Nashville, Professor Barnard had his first opportunity for systematic study, and most industriously did he follow out the study of literature, science and mathematics, and overcame the handicap of the gloom of earlier years, when he was only a star of small magnitude. He was not a variable star, but as years rolled on he increased in brilliance, and glowed in a constantly enlarging luminosity.

In 1888 he was appointed to the staff of the Lick Observatory. He eagerly seized upon all the advantages of this position, and became the foremost astronomical observer of his day, a worthy successor to the many torch-bearers who before him had lighted up many dark places in the field of astronomical research. He not only observed with his wonderfully keen and acute vision, but also made photography the handmaid of his scientific work. In this he was a pioneer in the use of the portrait lens. With this lens he revealed the structure of the Milky Way, and on 12th October, 1892, made the first photographic discovery of a comet. He was four years at the Lick Observatory before he made any observation with the 36-inch telescope, and in 8 days thereafter discovered the fifth satellite of Jupiter. When he was transferred in 1895 to the Yerkes Observatory with the 40-inch equatorial, his powers and opportunities for observing and discovery were largely increased. His capacity for work was most extraordinary—willing to work through 12 or more hours of a winter night in a dome, with a temperature sometimes lower than 20 below zero Fahrenheit, and there to sit hopefully and even joyfully at the photographic telescope through

an exposure of 6 or 8 hours. I cannot forbear quoting from Milton's Lycidas.

> Fame is the spur that the clear spirit doth raise,
> (That last infirmity of noble minds),
> To scorn delights and live laborious days,
> But the fair guerdon when we hope to find,
> And think to burst out into sudden blaze,
> Comes the blind Fury with the abhorred shears,
> And slits the thin spun life.

The pursuit of fame (although I do not think he worked for fame) by Barnard gave a mighty impetus to the never-ending quest into the secrets of the universe, for under such conditions his health must have suffered, and true it was that "the blind Fury with the abhorred shears" did slit the thin spun life. Under more favourable conditions for his unparalleled work he might have lived longer. His published contributions to Science number upwards of one thousand. Prof. Philip Fox thus recounts his many scientific triumphs:—

> He catalogued many dark markings of the Milky Way and has photographed not only nebulae, and comets, and the corona, but the moon in various situations, earth-lit, sun-lit, or in eclipse, meteor-trails, planetary surfaces clusters and nebula. He observed visually comets, following some of these month after month, the maximum period being that of the comet of 1888, his own discovery, which he followed for two years; planetary surfaces; interesting observations of the surfaces of Jupiter's satellites; the disappearance of Saturn's rings; the positions and light-variations of the novel. He measured many double stars, diameters of planets, their satellites and some of the asteroids. There is still unpublished his tremendous series of measurements of the positions of the stars in many star clusters, also the Milky Way Atlas, compiled from photograph made with the Bruce telescope of the Yerkes Observatory. These constitute two great unpublished investigations. Handicapped by the sorest distress and poverty from the first he fought the battle of life and was in the supremest sense a self-made man. He was marked by great simplicity of character, great modesty, perfect unselfishness and self-abnegation; a most kindly and genial spirit, most tender-hearted, making any distress of his friends his own distress of such character as to make him genuinely loved by all who knew him; his home was one of cordial hospitality.

These records would be imperfect without a statement as to solar eclipses. Barnard took part in three successful expeditions for photographing the solar corona at total eclipses. In the first on January 1st, 1889, observed in California, he secured some excellent plates. In the second, May 28, 1900, observed in North Carolina, he secured some very fine results. In the third, at Sumatra in 1901, he planned every detail with the greatest care for photographs of the corona on a large scale. The duration was very long, nearly six minutes. But Dame Nature, often coy and unapproachable, was in her very worst temper, and modestly but tragically veiled the sun with thick dark clouds and, nothwithstanding the great expense and infinite labour, refused to reveal her secret.

In the fourth, on 8th June, 1918, he was a member of the Yerkes party. The success was only partial. The sky was perfect in the afternoon but a great cloud drifted across the sun covering it until two or three minutes after totality was over.

Barnard, like Sir David Gill, looked at life from so many angles that he was indeed a human polygon. He was not an astronomer for gain, or even for professional renown, or self advancement. He was an astronomer because he could not help it. He sang the song of life just "as the linnets sing". In a word he did not live by Astronomy, but he lived for Astronomy. To him it was not only a sentiment, but a holy sacrifice; not only a feeling, but a fact; not only an emotion, but an energy. Duty is a word very much exalted in general estimation, but it is cold metallic and hard, although admirable. A man for duty only goes at his work with a tense nerve, a square jaw, a stiff back, and an iron resolution, and he no doubt may succeed, and he deserves applause. But it is hard work. It is pumping up results from some lower depth with infinite labour and perspiration, and even pain; but let love animate him, and his live is changed, and instead of a laborious uplift his life product pours down as from a crystal fountain, freely, fully and joyfully. And joy is much better than pain. Tennyson puts it thus:—

> Love took up the harp of life, and all its chords it struck with might,
> Struck the chord of self, which trembling passed in music out of sight.

Barnard loved his profession, and the whole world loves a lover. He worshipped his science, and the whole world reveres a worshipper—even indeed if they do not agree with him, or even understand him.

It grew late and dark with him on the 6th February, 1923. In the falling dusk he had a rendezvous with death, a rendezvous that no man can fail and he then heard the final bell.

The Book of Revelations speaks of a new heavens; it was then Barnard saw it, although from the great silence no record comes. Let us not forget the teachings of the night, nor can we forget the teachings that tell us of a never-ending day. Man cannot live by bread alone. He demands thought, and thought gives us faith, and Revelation with Faith and Hope gives us a vision that no reason can obscure. Science does much. Eclipses may be calculated, orbits of double stars may be measured, and intellectual conquests of a very high order may be achieved, but when we consider the vast problems of physics and astronomy, the Masters of Science are at the best,

> Children crying in the night,
> Children crying for the light,
> And with no language but a cry.

Our intellects are given to us to use them, to cope with lofty difficulties, and to surmount them; let us as humble students use what mind and gift and opportunity we have.

> God did anoint thee with His odorous oil,
> To wrestle not to reign.

It is the oil of the palaestra we have, and not the chrism of a king. Let us wrestle here valiantly, earnestly, honestly and prayerfully, no matter whether successfully or not, and we shall reign there.

Toronto, Ont.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

Autobiography of Professor Pupin

The present writer recently read the autobiography of Michael Pupin, published under the title, "From Immigrant to Inventor," and found it very attractive. It is interesting in several ways. It tells a very human story of a somewhat picturesque career in a simple and pleasing way. It also describes the scientific development in the generation just past of the wonderful electromagnetic theory of light, of which the foundations were firmly laid by Faraday, the plans were worked out by Maxwell and the structure was completed by Hertz. From this has come forth the marvellous inventions of wireless telegraphy and telephony.

Further, the book contains many bits of philosophy which have grown out of the author's experience and his consideration of the world about him. Many of them are very clearly and tersely put and I give two brief quotations, as follows:—

A Knowledge of Science Demanded

Every cultured person is expected to have an intelligent view of literature, of the fine arts, and of the social sciences, which is as it should be. But who has ever thought of suggesting that culture demands an intelligent view of the primary concepts in fundamental sciences? If cultured people had it, there would be no need to renew periodically the tiresome topic of the alleged clash between science and religion, and there would be much more straight thinking about things in general—p. 282.

Things Temporal and Eternal

Inventions are the handwork of mortal man and though at first they appeal to us, as they ought to, as wonderful creations of human ingenuity, their ultimate fate is to become more or less commonplace. The telegraph and the telephone, the dynamo and the motor, the light of the electrical arc and of the incandescent filament, had lost much of their awe-inspiring character when I was a student at

Cambridge [1884]. Inventions grow old and are superseded by other inventions, and, being the creation of the constructive schemes of mortal man, are themselves mortal. But the laws which the stars and the planets obey and have always obeyed in their paths through the heavens are unchangeable; they never grow old, and therefore are immortal; they are a part of the *eternal truth*. We do not know of any natural processes by which eternal things have been evolved. Their existence is the best philosophic proof that back of all this changeable visible world there is the unchangeable, the eternal divinity.—p. 220.

Completion of the Henry Draper Catalogue

The completion of this monumental work deserves notice. This catalogue contains the positions, magnitudes, and spectra of 225,300 objects. It is printed in nine volumes of the regular quarto size of the *Harvard Annals*, of which it forms volumes 91 to 99 inclusive. The first pages of the first volume were printed in August, 1917, and the concluding pages of the last volume were printed on June 14, 1924. The classification of the stars by Miss Cannon was begun October 2, 1911, and completed September 30, 1915.

The work was planned by Professor E. C. Pickering, with the assistance and advice of members of the Harvard Observatory staff and other astronomers; and the editorial work has been performed by Professor Pickering, Professor S. I. Bailey, Miss Cannon and the present director, Dr. Shapley.

Approximately 15,000 photographic plates were used for the work, made with various objective prisms, at Cambridge, Mass., and at Arequipa, Peru. The total cost of the catalogue is put at $250,000. It was largely paid from funds provided by Mrs. Henry Draper, though special gifts were made by Mr. G. R. Agassiz, Professor E. C. Pickering, Mr. and Mrs. C. W. Elmer and Mrs. James R. Jewett. Six hundred copies were issued and the printing was done by the Harvard University Press.

To supplement the Catalogue, particularly for faint stars in the Milky Way, an extension of the work is under way. It will be printed in small parts, and the first instalment may appear within a year.

C. A. C.

The Royal Astronomical Society of Canada

(OFFICERS FOR 1924—REVISED TO MARCH 1ST, 1924)

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